ARTIFICIAL

WARMTH & VENTILATION,

AND THE

Common Modes by which they are Produced.

BY

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INTRODUCTORY REMARKS.

There is no subject of a material nature to which such vital importance can with propriety be attached, as to that of the construction of our dwellings; for in them we are to live and find a home with our families and friends. And nothing connected with that home, its health, comfort, and happiness, can justly command the important considerations that are connected with the quality of the air—the element upon which chiefly depends the existence of those most dear to us, our wives and children, who spend the greater part of their lives within doors. Hence the artificial heat, which may make that air impure, becomes a subject of paramount significance.

In the Sun nature has kindly provided us with a magnificent warming apparatus, which alone, for a great portion of the globe, is all-sufficient. Through the day he diffuses genial and equal warmth, and at evening withdraws to permit the cool repose of the night. He gives a reflective and conductive heat, with the warmest rays nearest our feet, instead of our heads: the quality, too, is at once of the purest, and always below an excessive temperature.

But unfortunately for the inhabitants of that section of the earth in which we reside, the sun yields a sufficient external warmth but a small portion of the year, and we are compelled to resort to some artificial substitute for the remainder. We have that grand luminary and heater for a model, and the nearer we imitate him the nearer shall we come to perfection in the construction and application of artificial warming apparatus.

In speaking of the most common contrivances for creating artificial warmth, it is admitted that they all possess, to a certain extent, the superficial object to be attained, viz.: heating *power*. But this is in reality but an elementary principle, therefore we shall speak of qualities that are not so apparent, and leave the reader to exercise his own judgment in determining which plan comes nearest to the standard of the great prototype, the Sun, and combines the qualities appertaining to a perfect system for creating and maintaining artificial heat.

OPEN FIRES.

One of the earliest modes for warming, and one which at the present time is more universally adopted than any other, is the burning of wood or coal in an open fire-place at one side of the room. There are various modifications of this arrangement, dating all the way back from the primitive andirons, or fire-dogs, within an uncouth fire-place of clay or stone, to the modern grate with its glittering surroundings of silver and marble; but they are all subject to the following objections.

1. *Waste of fuel.* It has been found that in a common open English fire, seven-eighths of the heat produced from the fuel ascend the chimney, and are absolutely lost. This lost fuel is thus accounted for. One half of the heat is carried off in the smoke from the burning mass, one quarter is carried off by the current of the warmed air of the room, which is constantly entering the chimney between the fire and the mantel-piece, and mixing with

the smoke lastly, one-eighth part of the combustible matter is supposed to form the black and visible part of smoke, in an unburned state. Some writers have even gone so far as to estimate the loss of heat in an open fire at fourteen-fifteenths of the whole.

2. *Unequal heating at different distances from the fire.*—This forms a remarkable contrast with the uniform temperature in the air of a summer afternoon. In rooms with a strong fire, in very cold weather, it is not uncommon for persons to complain of being "scorched" on one side, and "pierced with cold" on the other; this is particularly the case in large apartments; for as the intensity of radiating heat (like light) is only one-fourth as great at a double distance, the walls of the room farthest from the fire are but little warmed, and therefore, reflect but little heat to the backs of persons grouped round the fire.

3. *Cold draughts.*—Air being constantly required to feed the fire, and to supply the chimney-draught, the fresh air which enters by the crevices and defects in the doors, windows, floors, &c., is often felt most injuriously as a cold current. "There is nothing more dangerous to health than to sit near such inlets, as is proved by the rheumatism, stiff necks, and catarrhs, not to mention more serious diseases, which so frequently follow the exposure. There is an old Spanish proverb, thus translated:

> If cold wind reach you through a hole,
> Go make your will, and mind your soul,

which is scarcely an exaggeration." The current of fresh air which enters to feed the fire becomes very remarkable when doors or windows are opened, for the chimney can take much more than it otherwise receives when the doors and windows are shut; and thus the room with its chimney becomes like an open funnel, rapidly discharging its warmed air.

4. *Cold to the feet.*—The fresh air which enters in any case to supply the fire, being colder and specifically heavier than the general mass already in the room, lies at the bottom of this as a distinct layer or stratum, demonstrable by a thermometer, and forming a dangerous cold-bath for the feet of the inmates, often compelling delicate persons to keep their feet raised out of it by foot-stools, or to use unusual covering to protect them.

5. *Bad ventilation.*—Notwithstanding the rapid change of air in the room, perfect ventilation is not effected. The breath of the inmates does not tend towards the chimney, but directly to the ceiling; and as it must therefore again descend to come below the level of the mantel-piece before it can reach the chimney, the same air may be breathed over and over again. In a crowded room, with an open fire, the air is for this reason often highly impure. As another source of impure air in a house, it may be noticed that the demand of the chimneys, if not fully supplied by pure air from about the doors and windows, operates through any other apertures.

6. *Smoke and dust.*—These are often unavoidable from an open chimney, much affecting the comfort and health of the inhabitants of the house, and destroying the furniture. Householders would make great sacrifices in other respects to be free from the annoyance of smoke. In large mansions, with many fires lighted, if the doors and windows fit closely, and sufficiency of air for so many chimneys cannot therefore enter by them, not only do the unused chimneys become entrances for air, but often the longest and most heated of them in use overpower the shorter and less heated, and cause the

shorter chimneys to discharge their smoke into the room.

7. *Loss of time.*—During the time every morning while the fires are being lighted, the rooms cannot be used; and there are, besides, the annoyances of smell, smoke, dust, and noise, all of which are again renewed if the fire is allowed to go out and to be relighted in the course of the day.

8. *Danger to person and to property.*—How numerous are the losses of property by carelessness as to fires is well known to all, while the less frequent but more distressing loss of life too well attests the danger to children, and to females thinly clad, often consequent on an open fire.

Such are the objections enumerated by Dr. Arnott, to which we may add, the annoyance and injury occasioned by the unavoidable ashes and dirt attending this mode of heating. Coal and kindling cannot be habitually brought into a nice room without injury to the carpet, aside from the liability of sparks of fire to fall upon it. What careful hand can remove the ashes and cinders, or poke the fire, without setting afloat a storm of ash-flakes, which settle upon books, furniture, &c.?

The danger to human life by exposure to open fires, is too well attested by the fact that nearly every newspaper contains the sad account of death from this cause. We copy from a city paper two melancholy examples:—

"Yesterday noon, Ellen Lynch, a child four years of age, living at No. 7 Clark Street, was left by her parents in a room with her little sister. On the return of her mother, the child was found dead on the floor, with all her clothes burned off, as is supposed in consequence of her dress having come in contact with the grate."

"A child two and a half years of age, left to itself, attempted to climb up on the fender, for the purpose of taking something off the mantel-piece, and in doing so fell inside, between the fender and the fire, and was thus roasted alive."

STOVES.

Next in the progress of improvement come the innumerable patterns of stoves. With the exception that they can be cheaply bought, and are somewhat more economical of fuel, their use is attended with all the evils of the open fire-place and grate, with the additional objections of taking up valuable room, being unsightly, and, worst of all, they produce some of the evils of the hot-air furnaces in presenting a heating surface, the temperature of which is sufficiently high to kill the animalculæ of the air, and scorch the myriad particles of dust floating therein, rendering it unfit for respiration, and so dry as to injure wood-work and furniture. The evaporating vessel of water on the stove is but a poor remedy for this evil. Stoves also come in competition with our lungs in the consumption of the oxygen of the air to support combustion, and do not recompense us for the loss, as in the ventilation which we get from an open fire.

Stoves, when the heating surface is so far extended by long lengths of smoke-pipe or otherwise, as to take up and impart directly to the space to be warmed, all of the caloric set free by combustion, are, of all methods, the most economical of fuel.

When stoves and open fires were first brought into use, it was through absolute necessity, instead of any merits which they chanced to possess. The latter came in vogue when wood was most abundant, and the fire-place was built capacious enough to serve the double purpose of cooking and warming. We date back but a few years to the first use of the grate, and the substitution of coal for wood.

Custom alone has familiarized us to the danger and inconvenience of these two methods of creating artificial heat. Should a stove, for instance, even of the most ornamental pattern, now be erected in our dwellings for the first time, its uncouth, black visage alone would be a matter of unendurable disgust. But when we take into account, above all things else, the thousands of human lives which statistics show are annually destroyed by exposure to open fires and stoves—children playing within reach of these fiery fiends—women drawn within their fatal circle—are we not led to believe that custom can habituate us to the most apparent and appalling of evils?

Here is a specimen of the old familiar story:

Ann Clifton, died at her residence, No. 43 Laurens Street, from the effects of burns received on Sunday evening, when her clothes took fire from a stove. Coroner's verdict, "Accidental death."—*Sun*, Jan. 24, 1860.

HOT-AIR FURNACES.

Of all potent inventions for the destruction of human life, which custom has tolerated under the head of "modern improvements," no one ranks higher than the common hot-air furnace. The evils *arising* from them are so numerous and so *glaringly* apparent, that we can conceive of no other reason for their general introduction than that they are "*cheap*." There are other arrangements for warming before the public, which are, at least, exempt from those intolerable objections which are inseparably connected with this; yet this Moloch of iniquity is still welcomed as a household companion because its first cost is small. When we take into consideration the great amount of fuel which they consume, the injury to wood-work and furniture, the high rates of insurance charged where they are used, the many valuable buildings they destroy by fire, and, above all, the invaluable human lives which are being daily sacrificed—*burnt-offerings* to this system—who can call them *cheap*, although their market value may be small? Men are wise in not employing them to yield warmth to the flowers and exotics of the green-house and conservatory. But human plants—flowers of immortality—may sicken by inhaling their polluted breath, and wither away under the Sirocco-like blasts of this abominable system of heating.

THEIR INJURY TO HEALTH.

The fundamental evil of hot-air furnaces lies in the very limited amount of heating surface they contain. The air we are to breathe should never come in contact with surfaces sufficiently heated to char the innumerable, minute, dusty particles of decayed animal and vegetable matter always floating therein. 250° is the limit to which any surface should be heated. Or it should be kept at a temperature so low, that, in ordinary cases, with the surface situated below, as hot-air furnaces are, 1 square foot of heating surface would be required (to give a sufficiency of heat in the coldest of weather) to every 100 cubic feet of space to be warmed. Take, for instance, a house containing eight rooms, averaging in size 16 feet square and 12 feet high=24,576 cubic feet of space to be warmed. This would require of heating surface, at a temperature of the above limit, 245 square feet; but a hot-air furnace of the size usually put in to heat such a house, would not exceed 75 square feet of heating surface. To make this small amount sufficient in cold weather, it is necessary to heat it to a temperature ranging from 800° to 1,000°. The baking temperature of an oven is 320°; wood will ignite at 350°; but what may be said of the healthfulness of air heated against surfaces which exceed the burning point of wood by 650 degrees! By excessive heating, the air itself is decomposed, its animalculæ destroyed, and their innumerable dead carcasses—if we may so speak—are thrown into the apartments being heated. The effluvia of the decomposition of this mass of animal matter constitutes a part of the disagreeable odor which escapes from the registers. Air being almost a perfect non-conductor of heat, one particle does not warm another; therefore the air which actually comes in contact with the over-heated furnace is the air by which we are warmed and which we inhale.

The leakage of gases is a gigantic evil of this mode of heating, and is inseparably connected with it. A furnace cannot be cast whole, and consequently it must have joints, which, by the continual strain of heating and cooling (expanding and contracting), will invariably become broken,—no matter how substantially they may be put together with bolts, screws and cement. These joints come against the fire on the inside, and the air to be heated on the outside: consequently, whenever a joint is broken, the gas from the burning coal is drawn, by the greater current of the air rushing upwards into the rooms that are being warmed.

A furnace may keep "gas-tight" for a few weeks, cr it may apportion out its gaseous poison in such perpetual regularity as to inure the occupants of the house to an unconsciousness of its presence; but a compound of carbonic oxide gas mingled with smoke and ash-dust, can be detected escaping from ninety-nine out of every hundred furnaces that are in operation, even by olfactory organs of ordinary ability. We were present, a few evenings since, at an evening meeting in a fashionable Church (but too poor to permit pure air and health to its members), where two ladies fainted by reason of the above-named evil; and the entire audience, no doubt, were affected to the extent of a headache apiece, from the same cause.

While thousands may be pining away by sure degrees through this domestic iniquity, the public are only startled by an announcement like the following—the death of two highly valued citizens. We copy from the *New York Times*, of Jan. 17, 1860:

"Mr. and Mrs. Sawyer, of Haverhill, Mass., died in their bed, on Saturday, 7th inst., in consequence of breathing coal-gas which escaped from a newly-erected furnace. When Mr. and Mrs. Sawyer were discovered in the morning, artificial respiration was unsuccessfully attempted as a means of restoring life. The air which escaped from their lungs was strongly impregnated with the gas which they had breathed."

There is also an *arsenical* escape from the highly heated iron, which, too, has its poisonous influence upon the air we are to breathe. And this is what dealers in hot-air furnaces call "*ventilation*"—a trite term emblazoned on their warehouses, as the surest decoy to catch purchasers.

Danger from Fire.—Another evil of the hot-air furnaces is their constant liability to fire the premises to which they are attached. The small quantity of fire-surface and heating-surface which they contain, renders it necessary to drive the fire to the highest point, in cold weather, and in moderate weather, the lack of any reliable control of the draft of the fire, with most of the heat shut back and concentrated at the furnace, engenders a dangerous heat, besides causing a wasteful consumption of fuel. These conditions, also, produce in the furnace and its surroundings a heat so intense as to open seams in the iron and brick-work, through which escape fire and combustible gases.

Many furnaces are erected without "double tops," or any separation between the furnace and the ceiling directly over it. Such are condemned by all insurance companies, and are pre-eminently dangerous. Nor is the danger confined to the cellar. The hot-air flies from the furnace at a temperature high enough to ignite any combustible thing with which it may come in contact. The tin-conducting pipes serve as protectors so long as they retain their bright reflective surface; but the various gases arising from the furnace, and the friction of the rapid current of air, soon change the bright, non-conducting surface of the pipes to dull conductors of heat, the solder will melt from the joints, crevices will be opened, and the contiguous wood-work set on fire. It has long since been ascertained that the continual action of heat will char tin and even burn it away. The pipes often become broken by the settling of the walls into which they are imbedded. It may with truth be said that it is hardly possible to erect a modern hot-air furnace without the liability of fire. Official investigation proves that two-thirds of the fires are traceable to this system of heating, and the fire insurance companies have been compelled to increase their rates where this kind of heater is used, while they offer a premium for safer modes.

The unequal distribution of heat is an important sanitary reason against the employment of hot-air fur naces in producing artificial warmth. The unnaturally heated air, rushing into the apartment with the velocity of a tornado, ascends at once to the ceiling, and, rendered specifically lighter than the air already in the room, it descends only as that may be displaced. The thermometer will, in a common room, indicate a difference in temperature of 10° to 15° between the floor and ceiling. Hence the headaches, dizziness, cold feet, and the many indispositions to which the occupants of such rooms are continually subject. There are other causes and conditions which operate to prevent this highly rarified air from being equally apportioned in an apartment; but were the air as pure as the element from which it was perverted, such inequality of distribution would be an unanswerable argument against the system.

The same pieces of iron that form the fire-pot also heat the air from which warmth is derived, and these in the hot-air furnaces can only be located in one and the same place, and such locality must, of necessity, be at very unequal lateral distances from the rooms to be warmed, with the hot-air conducting pipes of corresponding lengths. Rarified air has a tendency only to ascend and is incapable of being forced any distance in a horizontal direction, except through the application of some mechanical force. It will naturally rise through the first openings, hence the rooms nearest the source of heat, (the furnace,) are unduly hot, while those more remote may not be warmed at all. But if at times the distant rooms should receive a flow of heat, there is no certainty of their being thus favored again, as the force of such is so feeble, that some capricious current of air in the house, or some "ill wind" without, is sure to affect it. We lay it down as a positive rule, that to insure warmth to any space, the source of such warmth must invariably be located directly beneath or within it.

Unequal heights, also, are unfavorable to the even distribution of heat. One warm-air duct terminating at a higher point than another will have the greater flow of heat, on the same principle that a tall chimney will draw better than its shorter neighbor. In hot-air furnaces two conditions unavoidably exist to create this inequality in the upward currents. One is the unnatural lightness, and, consequently, buoyancy of the highly heated air; the other is the one hot-air chamber supplying all of the warm air ducts. So, in addition to our rule respecting the lateral conduction of warmed air, the same equality of condition must be maintained in its vertical distribution.

They do not ventilate.—Although the force which the hot air rushing in exerts upon the air in the room may expel it through some apertures of egress, and thus effect a thorough *change*, yet this does not constitute *ventilation* in the true signification of the term. The air is made no *better* by the process, but rather *worse*. The comparatively pure air of the room is merely exchanged for that which is contaminated.

Their irregularity of fire.—Subject to the capricious discretion of domestics, and without any self-regulating contrivance to check excessive combustion, the fire is left to a wasteful and dangerous irregularity. When you require the least heat in your apartment, the servant has *considerately* raked out the grate, opened the draft, and put on a surplus of coal; but, when you really want heat, the draft-damper *happens* to be closed, and the fire clogged, and, for all the servant knows, it is a mystery why the fire does not burn better.

The closing of registers and excluding hot air from the room, does not, as in the case of a well-constructed steam apparatus, have the effect to check the draft and deaden the fire, but rather to increase it, for the greater the heat against the furnace, the more the draft is accelerated and the hotter is the fire. With every means of escape closed, and a heavy fire raging, it may be readily seen that the air in the hot-air chamber and pipes leading therefrom would become dangerously hot; and, robbed of all its vitality, would, *in this instance at least*, become unfit for respiration.

The evaporating pan.—The evaporation of water from a vessel placed within the enclosure of the furnace, is but a poor remedy for the scorching of the air. The excessive and irregular evaporation, which is unavoidable, is frequently more objectionable than the over-dried air. The moisture is only *mechanically* taken up by the currents of air that may *happen* to come in contact with the water. This does not reinstate the original vitality of the atmosphere, nor recompense it for the loss of its natural moisture. Papered walls and furniture are often injured, and even ruined, by excessive humidity from this source; and its effect upon our personal health is certainly a matter of serious moment. The visible deposit of vapor on the windows and walls in the kitchen, is an apposite example of the effects of excessive evaporation.

Improved Combinations.—A great diversity of patterns, and many wonderful "scientific" and "philosophical" applications and "combinations" are displayed in each quarterly edition of this *modus operandi* for creating artificial heat. Some adopt an apologetic attachment in the shape of a few feet of steam or hot-water radiators; others vaunt themselves of some "self-cleaning" "gas-consuming," or "super-heated" paraphernalia, but they all amount to one and the same thing, and are subject to the same objections. We lay it down as an incontrovertible law, which will meet the approval of every candid mind that has given the subject a thought, that *no apparatus is fit to create artificial warmth for human beings, whose air-warming surfaces are contiguous to the fire and its attendant gas, smoke, and dust.*

Remarks.—Such are a few of the many evils connected with the use of the modern hot-air furnace; and yet, because their first cost is small, they are more universally used, in America, than any other heater that sends its heat up from below. But their employment is peculiarly an *American institution.* Intelligent foreigners attribute our bad health and complexions to their use. It is to be sincerely hoped that as the public become enlightened on the subject of artificial warmth, and the laws of health relating thereto; and as less objectionable modes of heating are brought within their reach, this unnatural arrangement will be consigned forever to oblivion.

HOT-WATER FURNACES.

For want of proper knowledge in the adaptation of steam for warming purposes, especially for domestic use, the hot-water, or more properly the *warm*-water apparatus has been resorted to by many as a remedy for the evils of the hot-air furnace.

Their merits consist in their being directly opposite in all their features to the hot-air furnace; and their demerits are that these opposite features amount to *extremes.* Their sins are rather of omission than commission. The heat they yield—so far as it goes—is of an agreeable and healthy kind. But the cold breath of winter does not agree with them, as the many inefficient members of this family now laid aside bear conclusive testimony. It has been properly styled "a warm-weather heater." The most approved patterns *do*, however, give heat enough *except* in very cold weather.

The hot-water apparatus is not of modern origin; it has been more or less in use almost from time immemorial. Its ancient usage was confined more particularly to green-houses, graperies, &c., &c. In this department it possesses some decided virtues. The warming surface in this case (usually consisting of four-inch cast-iron pipes) is placed directly within the space to be warmed, extending its entire length. The surface being ample, and the large body of water circulating freely through the pipes, an even temperature is maintained. This temperature can, by careful firing, with an ample supply of heating surface, be graduated to the requirements of most conditions of the external atmosphere. But this nicety of modification to any required temperature implies a skilful and ever-watchful gardener and fireman.

For warming private residences the pipes are generally smaller, and are located in the cellar, in the same position as the hot-air furnace. The air being but moderately heated, the pipes conducting it into the rooms are necessarily very large. The same necessity requires the heating surface to be very extensive, and consequently to occupy a large space, and involves a heavy expense in its construction.

Owing to a large body of water being heated, the apparatus is very slow in getting up its heat, but, as a partial recompense for this defect, it is equally slow in parting with it. Water is one of the best retainers or *bottlers-up* of heat, which fact argues against its efficiency as a heating agent—at least against its *rapidity* of operation.

Liability of freezing.—One of the most serious objections against this mode of warming, is the constant liability to freeze. So long as the whole body of water in the pipes is kept in circulation, this cannot, of course, occur. But the fire, which disturbs the equality of temperature in the water and causes it to circulate, is liable, through neglect or otherwise, to go out. Or if the fire be quite low, it may not cause a circulation, owing to the friction of water against the immense surface. The water always remaining in the pipes, and often remote from the fire—its exposedness to the out-door inclemency by means of a large cold-air box—the force with which the inward current impels it against the pipes—these circumstances combine to increase the liability of the water to congeal.

There is usually a damper in the cold-air box by which the out-door cold may be excluded, but its adjustment depends upon the servant, who, if careless enough to neglect the fire, would certainly fail to attend to this.

The high-pressure form of water furnace.—This is an arrangement whereby the heating pipes run through the house and are coiled directly within the various apartments to be warmed. It is the invention of Mr. Perkins, formerly of Massachusetts, but now of London, England. It is now nearly obsolete in the United States, although it was once adopted here to a limited extent. Some of the apparatus of Mr. Perkins are made to operate under a pressure of four thousand lbs. to the square inch. This plan possesses all the objectionable features of the other, with some additional ones.

Its liability to freeze is not as great, but the results are more disastrous. Where the pipes run to any considerable height, the hydraulic pressure on the lower part of the apparatus is very great; this, with the amount of expansion and contraction by heating and cooling of long lengths of pipe, creates a liability of leakage from the numerous joints, stop-valves, &c., which in nice rooms would be inadmissible. Such a large volume of water, extending, as it does, from cellar to garret, would, in a case of breakage, flood the house and furniture to their ruin.

No ventilation is produced by this system; and the coils in the rooms have to be covered by screens which take up valuable space and are not very ornamental.

Inequality of temperature of warm-water heating surfaces.—As the water in the tubes may have a graduation in its temperature, all the way from 32° the freezing point, to 212° the boiling point, it is impossible for it to maintain an effective heating surface against the ever-changing temperature of the out-door air which is drawn against it to be heated. We have in another place given a rule that the temperature of the surface against which air is to be warmed should hold the same against whatever change that air may be subject to, and the correctness of this rule we think must be obvious to all who have given the subject any thought. The cutting properties of an instrument become diminished as its edge is impaired; so with warm-water warming surfaces, the cold breath of winter blows over them, blunts their heating force—and a cold house and a cold day come together. Water may be any where in the scale of temperature from tepid or luke-warmth to boiling, and be warm or hot water still; while steam (as an opposite example) cannot exist at a lower temperature than 212°—a very effectual heating point. Even with the heating surface abundant, and the fire in good condition, the cold air will lower the temperature of the pipes to a very ineffectual point, and these conditions may be less favorable to an extent to admit of freezing, even while the water is travelling on its sluggish course. But steam apparatus with boilers properly proportioned to the heating pipes, keeps them fully supplied with steam, and the temperature of the surfaces is not at all diminished, let the air that comes against them be as it may.

Heat given off to no purpose.—Water being an excellent retainer of heat, as indicated by the long time required after the fire is built to make the heat available, and, consequently, equally tardy in parting with it, there is a decided loss in warming school-houses, churches, stores, and all places where warmth is required only a limited portion of the time.

For instance, a building requires warming but six hours out of the twenty-four; to do that with a water apparatus the fire must be built eight hours before the building is used. Now a good steam apparatus (a part of whose small body of water is converted into steam (212°) in a few minutes) is capable of warming the apartments sufficiently in two hours; consequently, it has but two hours to give off its heat to no account when the fire is allowed to go out, and warmth is not required; while water, with an excess of six hours in the commencement, has the same length of time (six hours) to waste its heat. This feature in the water apparatus, together with the lack of self-control to the fire, accounts for its extravagant consumption of fuel.

Its principal merits consist in the opposite conditions to hot-air furnaces in respect to extent and temperature of the heating surfaces.

The mongrel form of water furnace is a combination of surfaces heated by hot water, steam, and the fire itself. In some arrangements the last-named agent predominates; in others, the second. In one instance the air to be warmed, after passing over the red-hot surfaces of the hot-air part, is cooled or *tempered* against a meagre amount of water or steam surface; in another, it more properly passes *first* over the water surfaces, and afterwards over the steam surfaces.

Another contrivance is sections of cast-iron hexagonal-shaped flues, stacked together directly over the fire. Within these flues are sometimes placed strips of thin sheet iron, with a view of conducting the heat more rapidly from the *actual* heating surfaces. This apparatus has a steam chamber, blow-off valve, etc., and would more properly come under the head of steam heating. The air is drawn simultaneously over steam and water surfaces, and then against the bricks by which the whole is enclosed. The air warmed by this process is mixed up with a deleterious compound of water-heat, steam-heat, and smoke, ashes, gas, and other poisonous resultants of leakages from the fire-pot and fire-chamber. This system, besides its similarity to the hot-air furnace in collecting within its heating compartments the residuums of ordinary combustion, possesses a more dangerous feature in its confined steam than any steam apparatus now before the public. But so long as it goes under the pacific cognomen of "hot-water furnace," its true character will not be generally understood.

The evils of locating heating surfaces contiguous to the fire are most apparent. As we stated, in speaking of hot-air furnaces, the partition dividing the fire from the hot-air chamber will unavoidably become warped and broken. Whether they consist of brick, stone, or iron, the continuous action and reaction of excessive heat will soon break the joinings sufficiently to allow the escapement of gas, smoke, and ashes from the fire, to find their way into the hot-air chamber.

This evil exists to an inadmissible extent in nearly every heating apparatus yet erected, and is particularly flagrant in the above-named device. We think every intelligent mind will coincide with us on this point—that *even the liability* of leakages from the fire into the air we are expected to breathe, should not exist.

In point of durability, the water apparatus is defective when its heating surfaces consist of cast-iron tubes or sections. This is owing to the impracticability in foundries of casting even thickness in "core work." The adjustment of "cores" for a great number of pieces, especially if they are of considerable length, and have them maintain their positions during the process of casting, may be laid down as one of the impossibilities of the trade. Even should the core remain in its place, the fused metal in the progress of pouring and cooling, must, from well known practical reasons, attain an inequality both in surface and ductility. Thus alternately thick and thin, soft and hard spots will occur in this species of foundry work.

Tubes, or other cast-iron devices for heating purposes, are usually put together with cement, lead, cloth, India rubber packings, or some oxydizing preparations. Through the constant strain of heating and cooling, expanding and contracting, these joints will, sooner or later, become broken, or some of the more brittle portions of the surfaces themselves will crack, and leakage is the inevitable result.

Miscellaneous objections.—By using a large quantity of water, with no provision for drawing it off, sediment and mineral deposits will accumulate, and gradually im pair the efficiency of water-warming tubes.

The very large amount of heating surface which they present to the air, is objectionable from the dust and refuse matter continually accumulating thereon.

Hot-water operators find it impossible to keep the water just at its boiling and most available point, without its escaping in steam or overflowing; and the control of the draft to the fire in conformity with the heat required, has not yet been accomplished by them.

Experience does not prove that any form of hot-water apparatus is other than wasteful in the consumption of fuel.

LOW-PRESSURE STEAM-HEATING.

It is acknowledged by all those who are acquainted with the nature of steam, that it is at once the most efficient, manageable, and economical of all agents for communicating and distributing artificial warmth. It occupies the same superiority of position in the heating department that illuminating gas does in the department of artificial light. Being of about the specific gravity of gas, and of an elastic and volatile nature, it is peculiarly calculated to flow to the desired point, even through long and circuitous sections of small pipes. It expands seventeen hundred fold over the bulk of water from which it is generated, and, in returning to water, imparts one thousand degrees of heat to the air, which in water and in an uncondensed state would be latent and unavailable. It admits of the most compact form, both as regards the space occupied for its generation, and the surface to heat the air.

To construct a steam apparatus that shall be efficient, reliable in mechanical detail, and at the same time simple, substantial, economical, healthful, and perfectly safe, even in the hands of a common domestic—this is the great desideratum.

COST OF CONSTRUCTION.

A proper low-pressure steam apparatus cannot, if constructed of material of suitable durability, compete in point of *first expense*, with hot-air furnaces, high steam, or any form of warming where a small amount of surface (*by being over-heated*) is rendered capable of warming a large amount of air.

Where the temperature of the heating surface (which surface is the principal item of expense) is limited to a low and healthy quality, of course a larger quantity must be furnished than where the surface is heated to a much higher degree. The expense in the latter instance is *materially* lessened at the expense of health and safety. The same principle applies to the boiler that generates the steam.

If it be stinted in size and of small capacity, it will require frequent attention, be extravagant in the consumption of fuel, and furnish an irregular and unreliable quantity of steam. But in comparison with hot-water, or any apparatus which has a *superfluous* amount of heating surface—surface whose temperature is unwarrantably *below* the healthy point—the low-pressure plan can "under-bid"—the same space to be warmed, and all other things being equal.

SAFETY FROM EXPLOSION

To those not conversant with steam and its adaptability to domestic warming, the question naturally arises as to its safety when thus applied. The idea of "*explosion*" is invariably associated with the mention of steam boilers. In every instance where an explosion has occurred, steam was confined under a very heavy pressure; a large quantity was in the boiler, and that, for want of water, in immediate contact with an immense red-hot generating surface, with a fierce fire raging at the same time. With a proper low-pressure apparatus, there will be, *at all times, a directly opposite condition of things.* Instead of steam being under the pressure of 50, 75, or 100 lbs. per square inch, its highest possible pressure will not exceed one-tenth of the lowest of these figures, while every part of the apparatus is capable of sustaining a pressure of twice the amount of the highest figures. Instead of there being a million volumes of steam on hand at any time, one hundred would be the excess. Instead of the fire being driven to its highest pitch of intensity, (but lowest point of economy,) with a rapid draft, it burns very slowly, to a degree, and with a draft just sufficient to insure perfect and economical combustion.

The supply of water to the boiler requires no more care and skill than does the tea-kettle on the range, and its neglect would involve no more disastrous results.

But should a "bursting" happen at this low pressure, its consequences, compared with high steam, would be about as serious as the bursting of a pop-gun compared with that of a heavy piece of ordnance.

Steam, in the proper form for warming purposes, is even less dangerous than gas. During five years of constant experience in applying steam to private dwellings for warming purposes, and out of some two hundred instances where steam has been thus applied, the author has not known of a single accident from explosion, fire, or otherwise, where personal safety was at stake. Who can say as much of gas—not mentioning camphene, burning-fluid, and other dangerous substitutes?

SAFETY FROM FIRE.

There is a prevalent ignorance on this subject, even among men whose official positions ought to lead them to more extensive information. We will admit that steam has been known to set fire to buildings—water has done the same under like conditions. It is not the *kind* of apparatus, whether hot-air, hot-water, steam, or any other thing, that involves a dangerous condition from fire, but the *quantity* of caloric or heat which such apparatus or thing evolves. *Ice*, could it be heated to an equal temperature, would ignite whatever it came in contact with as readily as a red-hot iron bar. It is the *temperature* of the surface, let it be what it may, that implies danger from fire. That temperature, in the use of steam, generally depends upon the *pressure* which the pipes or radiators sustain, their thickness, the kind of material of which they are constructed, &c., &c. Yet pressure is not *always* necessary to produce high temperatures in steam. We have seen steam, under *no* pressure, and in the open air, ignite wood.* Steam, in its native and unconfined state, is a most effectual agent for *extinguishing* fire.

The following table shows, in round numbers, the temperature of steam under different pressures :—

At the natural pressure of the atmosphere, boiling point,				212°
At	1 lb.	pressure above do.		212°
"	5 lbs.	"	"	228°
"	10 "	"	"	241°
"	15 "	(The limit of a healthy temperature for any heating surface.)		251°
"	20 "	"	"	260°
"	25 "	"	"	269°
"	30 "	"	"	276°
"	35 "	"	"	283°
"	40 "	"	"	289°
"	45 "	"	"	295°

* Super-heated or sur-charged steam.

At	50 lbs.	pressure	above		301°
"	55 "	"	"		306°
"	60 "	"	"		311°
"	65 "	"	"		315°
"	70 "	Bread bakes and wood scorches.			320°
"	75 "	"	"		324°
"	80 "	"	"		328°
"	85 "	"	"		332°
"	90 "	"	"		335°
"	95 "	"	"		339°
"	100 "	"	"		342°

Thus it will be seen that the danger from fire in the use of steam depends altogether upon the temperature of the pipes in which it is confined, and that temperature (in common use) depends upon the *amount* of pressure of steam in those pipes. We can refer to a thousand instances where pipes containing low-pressure steam are run in every point of contact with wood, shavings, paper, and the most inflammable substances, and, after many years' use in such positions, they have not yet caused even "the smell of fire." The Board of Fire Insurance Companies of New York has recently decided this question in favor of low-pressure steam, and agrees to make a deduction of ten per cent. on all risks where it is exclusively employed for warming.

SELF-REGULATION.

This is the most important feature in the construction of a proper warming apparatus. All of the most common artificial heaters of the present day are without any such arrangement, and are unable to have it, for want of some available mechanical force. Steam is peculiarly calculated to effect this object, as the small amount of power requisite is easily applied, by a very simple mechanical contrivance, to shut off and reverse the draught to the fire, and to prevent any possible accumulation of steam beyond the desired limit, even more perfectly than an intelligent being, constantly in attendance, could possibly do.

It is evident that the fire should burn, and the fuel be consumed, only in proportion as heat is required. The quantity of heat thrown off from the heating surface depends upon the quantity of steam it condenses; and the extent of this condensation depends entirely upon the amount and temperature of the air coming in contact with the surface to be warmed. Thus, when a large amount of cold air is brought against the heating or radiating surface, the condensation is rapid, a large quantity of heat is evolved, the steam used fast, the pressure diminished, the draft opened, and the consumption of fuel increased. On the other hand, if the air to be warmed is taken against the surface at a higher temperature, and the amount diminished by its ingress being shut off from any room, the condensation is diminished, less steam is used, the pressure increased, the draft closed, and the fire checked to the requirements of the steam.

By this arrangement, it will be seen that steam is the regulator of the fire that generates it. This is all-important, as the fire is the prime mover, and no steam or heat can exist without it. On this feature depend safety, economy in fuel, general convenience and healthfulness. Without it no apparatus is complete, and no *steam* apparatus admissible. The mechanical construction of such an arrangement must needs be of the most simple, substantial, and reliable kind, and proof against any contingency.

ECONOMY IN FUEL.

By the perfect regulation and control of the draft, causing the fire to burn *only* as the demand for heat is required, and invariably closing when that demand is met; the water also from the condensed steam running back by its own gravity to the boiler, and constantly re-converted into steam, with only an incidental waste—and, consequently, not drawing upon the fire to heat cold water;—the proper construction of the boiler to insure the most perfect combustion, and the full absorption of the caloric of the fuel in the generation of steam—these are the principal conditions on which the consumption of fuel depend, and are all maintained in this apparatus to a degree of economy not equalled by any other.

By practical experience, the author is convinced that in the use of a properly constructed low-pressure apparatus, under like circumstances, one-half less the amount of fuel will be consumed than by a common hot-air furnace, and nearly the same ratio will hold good in comparison with hot-water and high-steam.

LIABILITY TO FREEZE.

This evil, which is such a serious one in the use of the hot-water apparatus, scarcely exists in this. Steam, of course, cannot congeal, and the water resulting from the condensed steam, running back to the boiler through warm pipes, certainly will not. There is only one condition under which freezing can occur in the arrangement under consideration, viz., when the boiler is located in an exposed place, and the fire is permitted to be out for several days, the small amount of water in it may freeze, though this may happen without injury to the boiler.

The draft of air through the cold-air duct to the heating surface is regulated by a damper operated by the pressure of steam, and is proportionate to the amount required to be heated—the same as described under the head of "Self-Regulation." Whenever the fire and steam go down, this damper is invariably closed, and the cold external air shut off from the heating surface. If but a part of the surface is filled with steam, or the ingress of warmed air into the room is stopped by the closing of registers, a corresponding amount of air is admitted. Thus it will be seen that this arrangement not only secures an even temperature to the air warmed, but prevents the liability of freezing from this source.

QUICKNESS OF OPERATION, AND STEADINESS OF HEAT.

Having but a small quantity of water to heat, and a large fire-surface wherewith to heat it, steam is quickly generated and distributed through the heating surface. From fifteen to twenty minutes usually will suffice "to get up steam" and make the heat available.

These causes also insure a steadiness of heat. By an ample fire-surface against a small body of water, the fuel is enabled, by burning at its *very lowest point of combustion*, to keep up the required head of steam; and this point is maintained by the control of the draft over the fire. Thus steam, and consequently heat, are kept up so long as there is any fire.

In this particular it has been claimed that the hot-water-furnace is peculiarly meritorious, especially for green-houses, (though we do not admit that steadiness of heat, and equality of temperature, are more essential to the well-being of plants than they are to persons;) that having a large body of water, it maintains its heat a long while after the fire goes out. This is true; but if it maintains it a long while after the fire goes out, it *re*tains it equally long when the fire is first built. On the other hand, steam is generated with the kindling of the fire, and goes down when the fire goes out. In this respect we claim a superiority for steam, for it is usually most desirable to have heat when the fire is built, and to dispense with it whenever the fire burns away, or is extinguished. Both systems create heat equally while the fire is burning, but the difference is at the *start* and at the *terminus*. One withholds it from being available at first, to give it off leisurely after the other has accomplished its duty. In the *aggregate* both systems evolve the same amount of heat under like conditions. The difference is only a matter of *time*.

FREEDOM FROM NOISE.

In the high-pressure form of heating, the noise occasioned by the collision of condensed water and steam being driven against each other, is very objectionable. The sound resembles the tapping of a hammer, and is continually kept up where long lengths of small lateral pipes are employed. In factories, workshops, and on steamboats, this noise may be admissible, but in private dwellings, schools, &c., never. Iron pipes, especially large ones, run to the different rooms of a dwelling, are objectionable in being such good conductors of sound. The least rattle of coal or other noises at the boiler, can be heard quite as distinctly in some distant room as where it occurred. Neither of these undesirable features exists in this plan. The pipes are so arranged, and of sufficient size, and the pressure in them so slight, that the flow of the steam upwards, and of water downwards, is free and noiseless.

SIMPLICITY AND EASE OF MANAGEMENT.

To have a heating apparatus—especially one that otherwise would be dangerous—simple and substantial in its construction, not liable to get out of repair, and entirely secure in the care of common domestics, is indispensably essential. This apparatus combines these necessary features. The fire requires to be fed, to keep up an even supply of heat, but twice in twenty-four hours. A fresh fire will seldom need to be built.

There are no valves or dampers whose adjustment depends upon the care and judgment of any one. Only the simple and all-important items of fuel and water are required to be supplied. The supplying of these *must*, under any circumstances, rely upon human intelligence. No contrivance, though it be as perfect as mechanical skill can construct, is *infallible*, therefore none should be intrusted to fulfil this indispensable duty. The habit of the common domestic in the kitchen, of supplying with punctilious regularity, every morning, the water to the tea-kettle, and the fuel to the stove, amply qualifies her to attend to this duty—no more skill, judgment, or trouble is required in one case than in the other.

The simple act of shutting off or letting on the heat, by turning the registers, whenever agreeable to the occupants of any part of the house, does, of itself, regulate the fire, the accumulation of steam, and the amount of air to be warmed, as before explained.

DURABILITY.

Where a considerable expense, as well as some trouble is involved, we want, besides the assertion of "for value received," an *assurance* that such is the case, and that what we buy will, besides *appearing* all right, be in reality of some *lasting* benefit. This is particularly desirable in a heating apparatus which is put into a private dwelling. Outside of the first cost, its erection is attended with more or less inconvenience and annoyance to the inmates. Some tearing away, altering and repairing of wood-work, brick, stone, &c., is also implied in the operation.

The simple fact that this apparatus is capable, in all its parts, of sustaining a pressure of two hundred pounds to every square inch, must be proof abundant and apparent of its durability. In short, the boiler, heating surface, and all the appurtenances connected, will last and hold good at least the average life-time of man.

HIGH-PRESSURE STEAM-HEATING.

We will briefly speak, by way of comparison, of a system of steam-heating which is directly opposite in all its features to the one we have been considering.

Most persons have but a superficial knowledge of steam, and of course are ignorant of its different forms of application, both as an agent for heating purposes and as a motive power. All are familiar with the sight of the long lengths of small pipes running beneath the seats of steamboats, and around the rooms of factories and many other large buildings. This is the high-pressure application of steam-heating, and has been in vogue for a great many years.

The steam is generally supplied to these pipes from the same boiler that furnishes steam to drive the engine, and they are subject to the same heavy pressure. This plan is a convenient one where a steam engine is required, but the objections to it make it hardly admissible under other circumstances.

Disagreeable Noise.—The pipes, sustaining a high pressure, usually about fifty lbs. per square inch, and extending long distances in a level position, are liable to a constant noise resembling the tap of a hammer on the pipes. This disagreeable sound is caused by the steam coming in contact with the condensed water in the pipes, and which must be forced forward by the pressure of steam, as the horizontal position of the pipes will not admit of its running off by its own gravity.

Health and Appearance.—The temperature of the pipes, under this pressure, is too high (300°) for a healthy and agreeable heat. The dust settles upon them and becomes burned, which, with the heating over and over again of the air of the room that is inhabited, occasion an offensive and unhealthy effluvia.

The pipes are sometimes stacked up in short lengths, and covered with an iron screen, mounted by a marble slab. This is the customary mode in stores and hotels. The naked pipes, as well as the common clumsy patterns of screens, would have an objectionable appearance in private apartments.

The Consumption of Fuel is much greater in a high pressure than in a low-pressure apparatus. Both philosophy and practice prove that in proportion as the pressure of steam is increased, the ratio of fuel required to give a certain amount of heat is increased, and *vica versa.* The *sensible heat*—the temperature of the heating surface—may be increased, while the *latent heat*—the great available principle in steam as a heating agent—is diminished. The amount of steam *compressed* in one instance, and the amount of steam *condensed* in the other, are relied upon for heating power.

Pressure involves fire, and fire fuel. The greater the pressure the less the quantity of available heat in proportion to the fuel consumed. In proof of this position we would refer to two buildings in New York, in both of which steam is employed to warm about 700,000 cubic feet of space. In one, the apparatus never exceeded 2 lbs. pressure to the square inch, in the other the pressure ranged about 60 lbs.

The amount of coal consumed during the same length of time (one season), with the other things being about equal, was one-half less in the low-pressure apparatus (70 tons) than the high-pressure (140 tons). We do not refer to this as a fair experimental example, as there were qualifying conditions, such as the more perfect regulation of the draft, &c., &c., in favor of the low-pressure apparatus; yet a fair test, under equally favorable circumstances, will prove the above comparison nearly correct.

Attention Required.—The supply of water must be maintained by the use of a power-pump, to force the water into the boiler against the pressure of steam. The constant watchfulness of an engineer is demanded to attend to this, and to keep the fire fed with fuel. The valves, also, in the different return-pipes of the boiler, need to be opened to ventilate the heating-pipes of air, and shut when the air is out, to prevent the steam from escaping.

Smallness of Boiler.—Here is a universal and most serious evil in the erection of the high-pressure apparatus. The fire-surface being too small, the deficiency must be made up in the *intensity* of the fire. With the very strong draft necessary, the combustion is hurried, and consequently there is a large escape of partially consumed fuel up the chimney. But with boiler capacity sufficiently large to admit of slow and perfect combustion making the requisite amount of steam, the unconsumed particles, which in the other instance are lost, would be retained and burned, thus saving fuel, the labor of putting it on, and lessening danger.

The intensity of the fire, and the rapid generation of steam, impair the boiler by throwing off the water from the fire-surface immediately contiguous to the fire, and exposing those parts, thus rendering them liable to burn.

The smaller the boiler, the less the cost of construction. The expense of the boiler is economized by the man who erects it, at the expense of the man who is obliged to furnish fuel for it.

The danger of Explosion attending this Plan is owing, in a great measure, to the furious fire consequent upon the use of too small a boiler. A certain amount of steam is required, and a small surface is, by being overheated, taxed to its utmost capacity to furnish it. The fearful results of explosion are attributed to an explosive gas being generated by the throwing of water upon exposed red-hot surfaces, when the water becomes too low, and a large amount of dry, surcharged steam is packed and confined within a very small space. An excess of pressure, merely, would cause a bursting at the weakest point, and the pressure thus being relieved, nothing more serious would result.

The danger from fire by this system is explained in speaking on the same subject in connexion with the use of low-pressure steam, page 24.

SUMMARY REMARKS.

There is at the present time a general dearth of good artificial heaters. Steam, as the agent for heating, is rapidly growing in public favor, and must eventually supersede all other modes, although it is, as yet, only in the incipient stages of development. The field is so broad and inviting that ambitious adventurers are plenty, each sanguine of ultimate success in attaining the much-desired object, viz., the construction of a *cheap* and *perfect* steam apparatus. Most of them are entirely successful in obtaining the *former quality*, but fall lamentably below the standard in the *latter*. Many are the devices concocted within prolific brains to effect this object, and most as frequently is recorded the untimely birth of some alien to the legitimate household of heaters. Happily however, for the public, they seldom attain any further state of development.

Steam for mechanical applications, and steam for warming purposes, do not go hand in hand. The offices of one disqualifies it for the proper duties of the other, and *vice versa*. Theory, practice, and philosophy, all agree on this point. Low pressure for warming—high pressure for mechanical force.

Steam in its natural, uncompressed state, (212° the same as the highest temperature of water), imparts to the air a mild, healthy, and agreeable heat. Hot water does the same, but is less efficient, and liable to freeze. There is no danger from fire by either of these two modes.

High-pressure steam or water may be dangerous from fire because of the high temperature of its surface. By excessive pressure, they may have some of the unhealthy and dangerous qualities of the hot-air furnace.

The limited amount of fire-surface and heating-surface is a very serious deficiency in almost every heating apparatus of the present day. Where a small surface is required to do a large amount of warming, it must of necessity be heated to a very high temperature. This is done not only at the expense of fuel but of health. This evil grows out of competition in the trade to get up as cheap an article as possible. But many have found to their sorrow that an apparatus stinted in surface is the dearest one of all. The combustion is imperfect by being too rapid, and a large quantity of fuel escapes and is wasted, which with a slower fire would be burned.

The fuel also has to be often replenished, and a decided loss of heat is incurred by the frequent opening of the furnace door, and the repeated kindling of fresh fuel.

In hot-air furnaces the fire-surface is but the other side of the heating-surface—hence the intense heat that burns up the air, as well as the furnace itself.*

All heating apparatuses, especially those intended for domestic use, should have sufficient heating capacity to allow the fire to burn very gradually—so gradually that it need not, in ordinary weather, be replenished more than twice in twenty-four hours.

It is very important to have the hall, which is the great artery of a house, properly warmed. On the temperature of this—extending as it generally does through all the stories—to a great extent depends the temperature of the whole house. In fact, a house can be tolerably warmed by steam, and at a very small expense, from the hall alone.

VENTILATION.

This is a subject on which a great deal of time, talent, and ink have been wasted. The acceptable meaning of

* We have seen them so rotten as to literally crumble to pieces by their own weight.

the term is simply to keep the air of all artificial habitations in its natural condition—as pure as it exists in the broad expanse of space. To effect this object much labor has been spent, and many ingenious plans devised. Some have been successful to a certain extent, but most of them have failed of attaining the desired object, by being too complicated, expensive, &c.

Impurities to which we are subject.—The principal sources of impurities from which in-door air requires to be freed by ventilation, may be briefly summed up as follows:

1. Expiration from the lungs of persons and animals.
2. Perspiration (sensible and insensible) from persons and animals.
3. Stoves of all kinds.
4. Hot-air furnaces.
5. Fumes and vapors from the kitchen.
6. Artificial illumination.
7. Unnatural dryness of the air.
8. Unnatural humidity of the air.
9. Evaporation from human and other bodies.
10. Decomposition of organic substances.
11. Stagnant air.
12. Damps of cellars and basements.
13. Sickness, fumes of medicine, &c.

The extent to which these impurities exist under an innumerable variety of conditions and contingencies, and in different localities, we will not attempt to define.

The amount of provision requisite to be made for counteracting the pernicious effects of the above-named causes, depends altogether upon the necessity existing in each individual instance. In hospitals, school-houses, public buildings, and all places where a large number of persons are congregated, the contamination of air is very great, and corresponding provision should be made for ventilation.

In private houses where but few reside, and where few sources of contamination exist, less effective means are required to ensure proper ventilation. The remedy must in all cases be commensurate with the requirements, and this must, in a great measure, be left to the good sense of those whom it immediately concerns.

Merely changing the air does not constitute ventilation. The air may be often changed and still be more impure than in a stagnant or otherwise perverted state. Hot-air furnaces give a copious change of air to the apartments, and their venders are loud in proclaiming the importance of ventilation, making a virtue of necessity, to effect the sale of their wares. The remedy is worse than the disease in this case. The heated, gaseous air thrown up from the furnace is most unhealthy, while the air it displaces in the room is comparatively pure. A *change* in the air is effected, but *ventilation* is prevented.

Equal temperature necessary. The air of a room may be changed, and all its impurities be removed, and it still be in an unhealthy condition from an uneven temperature. A cold current may be circulating through it in one part, and a warm current in another. The tendency of all artificial heat is favorable to this evil. Heated air naturally rises, and the upper strata in an apartment will be warmer than the lower, unless counteracted by some artificial process.

Very much depends upon the condition of the air warmed, whether it be deprived of its natural moisture, and thus rendered specifically lighter, or warmed merely without interfering with its natural state. The heat from hot-air furnaces and stoves is, of all others, the least calculated to distribute itself in an apartment. Besides, the air being deprived of its moisture by coming in contact with over-heated surfaces, the gases are deranged, and its natural gravity thus lessened.

THE NECESSITY FOR VENTILATION IN PRIVATE HOUSES.

Here the principal contaminating influences to provide against, are those which emanate from the human system, and from artificial heating and illumination. Taking the average opinions of the best authorities, a common grown person will vitiate and render unfit for respiration 7 cubic ft. of air per minute.

The natural causes of impurity from the human system are:

Consumption of oxygen (the vital element of the air) by inspiration; emitting carbonic acid by expiration, insensible perspiration; and "the peculiar effluvia of the living body."

Thus a single person would, in 6 hours, destroy the air contained in a room 16 ft. square and 10 ft. high.

But we ought not to limit our lungs to the smallest amount of pure air which the constitution can tolerate without perceptible injury. "It is evident that the nearer the air within-doors approaches in purity and freshness the free and open atmosphere, the better will it conduce to health, strength, and length of life." To maintain the highest state of health through our respiratory organs, the air with which we come in contact at one moment, should be exchanged for fresh air the next. It should instantly be carried off and as often renewed. With every inspiration of the lungs we irrecoverably take from the air a portion of its vitality; with every expiration we actually poison it.

A candle (6 to the lb.) will consume one-third of the oxygen from 10 cubic feet of air per hour. Oil lamps with large burners will change in the same way 70 ft. per hour. Gas illumination produces the greatest changes in proportion to the light evolved. Every cubic foot of gas burned imparts to the atmosphere one cubic foot of carbonic acid. A burner which consumes four cubic ft. of gas per hour, spoils the breathing qualities of 400 cubic ft. of air in that time.—YOUMANS.

The injurious consequences of foul air. By breathing foul air, almost every species of diseases is engendered; among the first of which are cholera, consumption, fevers, scrofula, and all the various difficulties of the lungs and throat, and infant mortality. It disorders and prostrates the physical constitution generally, and has a degrading and debilitating influence upon the *mental and moral* faculties.

Therefore it is not possible to obtain *too much* fresh air, though to obtain a large amount properly warmed, in cold weather, is a matter of serious if not *expensive* consideration.

The *modus operandi* whereby to effect the desired change, purity, and even distribution of air artificially warmed, must be taken into consideration. On the principle that "like cures like" we must employ some artificial process as a remedy. It would be futile to attempt to define any particular process of ventilation which would be applicable in all cases.

As heated air has a tendency to ascend, vents or escape-pipes should, in ordinary cases, be provided near the floor. This will counteract the rising current, by creating a downward draft. The heaviest and most noxious gases floating in the lower part of the room are also drawn off. Other vents should be provided near the ceiling, for summer use, in connection with the lower ones.

As artificial ventilation involves motion of air produced either by heat or some mechanical force, artificial heat, by being constantly in domestic use, is the most economical and available agent; and a proper warming apparatus becomes a convenient and important auxiliary, and may be arranged to perform both duties satisfactorily.

Artificial Ventilation and Cooling in Summer Time.—When the public become more convinced of the importance of proper ventilation, and are willing to be at the *expense* of pure air instead of lavishing money on useless decorations, we may expect to see, in common use, artificial appliances for a more thorough and steady change of air in warm weather.

This can be effectually and safely accomplished by rarefying a shaft of air leading from the various rooms to be ventilated, by means of steam-heated surfaces placed in a ventilating dome on the roof, or in a chamber in the garret, through either of which the shaft or shafts may find an external opening to the outer atmosphere. Or a cheaper, if not more effectual mode, is to have *double chimney flues*, by enlarging the common kitchen flue sufficiently to admit an interior one to be used exclusively for the smoke and products of combustion. Into the outer flue, vents may be opened from all the different rooms, and the ordinary fire used for cooking and laundry purposes will rarefy the air and create a good draft. To accelerate the draft, and increase the power of ventilation, the additional heating surfaces, as in the former arrangement, may be applied. Of course these vents from the rooms must have corresponding inlets from out-doors, which are provided in the flues, that, in cold weather, bring the warm air into the rooms from the heating apparatus.

Adopting either of these plans would obviate the necessity of opening windows and doors, which let in dust and noise, and unpleasant odor from the streets, and which are so convenient for burglars. It would also prevent the unequal currents of air from those openings, and insure a regular change, whether the out-door atmosphere be in motion or not. The air to be drawn through a room may be cooled to any extent by causing it to pass over ice; it may also be purified by being filtered through charcoal. Both of these operations are practical.

Ventilation involves Expense.—The real practical difficulty in ventilation is its cost. Although the atmosphere is everybody's property, and is the cheapest of all things, yet a supply of pure air in dwellings is by no means free of expense. To insure ventilation we must have motion of air, and to produce motion demands force, which is a marketable commodity. Whatever will produce available force has value in it. Whether it be fans and pumps driven by steam-engines, or upward currents set in motion by naked fire, in both cases there is expenditure of fuel. It is true we may use the fire that must be kindled to produce warmth, and thus secure the additional result of ventilation, apparently without an additional cost. But in most cases foul air is also warm air, and in escaping conveys away its heat, which is thus lost. Contrivances have been proposed by which the out-flowing warm air may be made to impart its heat to the in-coming cold air, but they are not yet reduced to practice. Until this is done heat must continue to be lost by ventilation just in proportion to the extent. Hence, as was before remarked, ventilation may be classed with food and apparel, and it becomes a question of how much can be afforded. But there is this important difference, that while economy in the latter—a plain table and coarse clothing—are at least equally favorable to health, with more expensive styles of eating and dressing, economy of ventilation, on the contrary, that is, any cheapening or deterioration of the vital medium of breathing, is injurious to health. One of the worst evils of scarce and expensive fuel is, that the poorer classes feel compelled to keep their rooms as tight as possible, to prevent the escape of warm air and the consequent waste of heat.—*Youmans.*

RADIANT HEAT.

Air and objects are warmed from sources of heat by convection, conduction, radiation, and secondarily by reflection. All heat that is to any extent effective in yielding us that warmth which we require in addition to the inherent heat of our bodies, is through the first-named means.

All contrivances in vogue for creating in-door warmth, warm us principally through the air first being brought by circulation in actual contact with their heating surfaces (convection).

The extent to which heated surfaces radiate depends, practically speaking, upon the temperature of such surfaces. A bed of red-hot coals, as in the open fire, is the most powerful radiator in domestic use. This is due, not only to their high temperature (1,200° to 2,000°), but to the multiplicity of angles of radiation which the variously shaped pieces of coal present. But the radiation from this, the most powerful of radiators, is, as we all know, quite small, and the quantity of fuel consumed, compared with the amount of heat afforded, enormous. Some investigators estimate that as much as fourteen-fifteenths of the heat set free by combustion escapes up the chimney, and is lost.

The ordinary fire-place at one side of the room is a good example of the extent to which radiant heat is available for heating purposes: for here, owing to the draft up chimney, all the heat yielded by conduction and convection is lost, and all the heat distributed in the apartment is through radiation. Ten feet distant and within the direct line of its rays, is as far as we can expect to receive any beneficial effect from this source. Surfaces of a lower temperature would be proportionably ineffectual.

The heat-*rays* from a steam heated surface at 200° could hardly be detected at a distance of two feet. In fact, were a strong current of air passing over such surfaces and up chimney, as in the open fire-place, freezing might occur within a few feet of them.

The heat we get from a steam radiator, as before stated, is from *convection*—the circulation of air against it. In proof of this, we have found that, in actual practice, a room is quite as well warmed, as otherwise, with the front of the radiator screened, and all extension of *rays* prevented, sufficient space, of course, being provided for the circulation of air beneath.

The *theory* of radiation, as put forth by some very learned but very *unpractical savans*—that rooms are warmed by rays from steam radiators as the earth is warmed by rays from the sun, is very fine; but in practice we would be very liable to suffer with cold, notwithstanding this benign result. "It is believed that the sun's rays do not heat the regions of space, and the earth's atmosphere is heated almost entirely by contact with the surface of the heated earth."—*Silliman's Chemistry, revised edition, page* 57.

Radiant heat alone is objectionable in a sanitary point of view, from the great inequality of temperature at different distances from the source. "The intensity of radiating heat (like light) is only one-fourth as great at a double distance."—*Arnott.* Thus taking the temperature at one foot distant from the radiator to be 80°, at two feet it would be 20°, at four feet 5°, and so on in an inverse ratio.

Rays of heat warm only that part of an object that comes within their direct range. In facing a radiator the face is heated while the back is cold. "The difference is exactly like that betwen being in the shade and in the sun." We cannot endure the direct rays of the summer's sun, but when we are protected from them, and are within the genial influences of warmed air, that affects every part of us alike, no better condition of warmth could be desired.

To have a room and its occupants evenly warmed by artificial radiation alone, it would be necessary to have the entire walls, ceiling, and floor, covered with heating surfaces, that the rays diverging from them may equalize the temperature, and strike every part of the person at the same time.

MISCELLANEOUS REMARKS.

A room may be thoroughly ventilated without being at all heated; or it may be thoroughly heated without being in any way ventilated—the latter is too often the case. But the effective and harmonious operation of the two systems are indispensable, in cold weather, to health and comfort.

In ventilating in connection with heating, a few general rules should be observed. The air should be obtained pure, and retained pure in the process of heating. It should also be evenly distributed while passing into and out of the rooms. The flues that conduct the air in to be warmed, should have their external openings from some high point above the line of dust, the products of decayed animal and vegetable matter, and the obnoxious gases which float near the ground. These flues, as well as the ones that take heated air into the rooms, should have sufficient capacity to admit the requisite amount of air to pass through them without creating a rapid current.

Although the cold-air duct should be of sufficient size to supply all the hot-air vents through the building, yet that supply should be varied with the demand. When a part of the warm-air registers are closed, a corresponding amount of air should be excluded from the cold-air duct as well as from the fire. When the fire goes out, the cold air should be entirely excluded. This arrangement is effected in this steam-heating apparatus, and its advantages are obvious. An equal temperature of the warmed air is maintained, fuel is saved, and freezing avoided.

The surface against which the air is warmed should never exceed the temperature of 250°; and an ample quantity should be furnished at this limit, to properly warm, in the coldest of weather, all the air that may be required.

We may have the temperature of the heating surface higher without injury, provided that, in no instance, is the air liable to be confined in contact with it long enough to attain the same degree of heat. But this liability always exists.

Artificially warmed air is generally about 60° below the temperature of the surface from which it is heated. But when it is confined, as in the case of all the registers for its escape being shut, and the fire at the same time unchecked, not only an unhealthy but a *dangerous* heat is engendered, where the temperature of the heating surface exceeds the above-named limit.

The heating surface should never be located contiguous to the fire; it should be several feet remote. This obviates the liability of gas and smoke incidentally escaping, finding their way into the hot-air chamber. There is also less liability of firing any wood-work that may form a part of the heating or ventilating arrangement.

Each strata or volume of air, as it floats against a heated surface, is rarefied by imbibing some portion of caloric, and at once ascends, making room for the denser or colder air, which in turn flies from the hot surface, thus creating a circulation that continues until an equilibrium of temperature is established. The rapidity of the circulation depends upon the difference of temperature in the room being warmed and the heating surfaces, when such surfaces are located within the room.

When the heating surfaces are placed within a chamber or chambers of their own, and out-door air is supplied to them, the rapidity of the circulation is proportioned to to the temperature of the exterior air, its condition in respect to motion, moisture, etc., and the size length, position, and construction of the ducts for ingress and for egress. Much also depends upon the kind of heating surfaces, their shape, position, and extent; also upon the character of the apartments into which the warmed air is to be discharged, in relation to outlets, windows, and other condensing objects and exposedness.

In order to maintain a rapid, reliable, and consistent flow of warmed air, it is requisite that the heating surfaces retain a uniform as well as an efficient temperature against the variableness of the outer atmosphere.

Hot water has neither the power to maintain an even and adequate temperature against severe influences, or to be to any practical extent self controlling. (See page 20.)

Hot-air furnaces, while they have *power to heat*, lack the power to control the fire; consequently, the heating surfaces, whose temperature depends upon the condition of the fire, will get unhealthily, dangerously, and wastefully hot. (See page 15.)

Steam is peculiarly calculated to fulfil these requirements, and is, in fact, the only agent that is capable of accomplishing the desired ends in a warming apparatus. It creates a moderate, agreeable, and, at the same time, a proper *quantity* of heat, while it has, within itself, the necessary mechanical force, which is easily applied, to open and shut the draft to the fire, and thereby control it in exact conformity to the desired conditions of the different parts of the heating and ventilating arrangements. (See page 29.)